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Global Prospects for the Development of Unconventional Gas

Jan Bocora*

University of Economics in Bratislava, Dolnozemska cesta 1/b, Bratislava 852 35, Slovak Republic

Abstract

The fast and large-scale development of unconventional natural gas in North America created a new geopolitical and economic situation in the world. Discovery of large deposits of shale gas triggered a quiet revolution on the local market. Unconventional gas in its various forms has also been found in other parts of the world, giving an opportunity for many countries to lower their import dependence and strengthen their energy security. The rise of unconventional forms of oil and gas and a fast shift from the traditional producers to plentiful domestic resources could present the beginning of a new era in global energy affairs. But the extraction of these resources has also been marked by different attitudes of political elites, business representatives and the public, mostly because of their economic and environmental impacts. In this paper, we will focus on the global perspective of the development of unconventional gas based on the assessment of relevant risks and implications on a global scale.

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1. Introduction

The global energy landscape has changed significantly in the last few years. Fast growing demand for oil mainly from the emerging economies like China or India has caused record high prices of energy products, global financial and economic crisis and the uprising in the Arabic countries resulted in wide price fluctuations that destabilized the world markets, a natural disaster in Japan ceased the nuclear renaissance and initiated a global rethinking of nuclear energy as a safe and cheap option for producing electricity. In

* Corresponding author. Tel.: +421-908-656-262
E-mail address: jan.bocora@gmail.com

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addition, one similarly important development took place in the world, which could change the current international energy landscape – the development of unconventional oil and natural gas.

Driven by rising prices and advances in geosciences and technology, reserves have continuously skipped from unknown (new discoveries in new territories), through technologically or economically unavailable (unconventional reserves) to conventional (largely available with current technology and at current price and cost level) (Rogner, 1997). This evolution has also been decisive for the development of unconventional gas in the recent years, which has been influenced by many factors such as technological progress, economic incentives or political and environmental lobby. Kefferpütz in his analysis suggests several factors that have led to the fast development of these resources (Kefferpütz, 2010):

- Fast and accurate identification of the potential of the unconventional resources, mainly of shale gas in the US, followed by a global initiative in other parts of the globe, mainly in Latin America and Asia;
- Fast technological progress in drilling techniques (reintroducing horizontal drilling and hydraulic fracturing, also called fracking);
- The vision of high revenues for upstream companies, taking into account the growing demand for natural gas as a cleaner substitute to oil and coal and a safer alternative to nuclear;
- Development of existing pipeline networks and local infrastructure;
- Growing political support in the wake of a turbulent development in the largest producing regions.

Unconventional gas can unlock a whole new scenario on the global energy market, disrupting the current energy flows and introduce a new paradigm for security of supply, based on abundant domestic resources and a new composition of the global energy mix with natural gas as the leading form of energy. The role of natural gas will increase, particularly in the context of a highly desired new climate change legislation and green house gas (GHG) regulation. However, the question is whether natural gas should present the dominant form of relatively clean energy in the future or should just create a basis for the next energy revolution based on renewable and green energy. Therefore, the aim of this paper is to rethink the global perspective for the development of unconventional gas, whilst we will focus on several aspects:

- Geology and the transparency of the current reserves in the world;
- Economic implications of unconventional gas production;
- Environmental concerns related to water management and emissions; and
- Geopolitical implications as a result of the changing global patterns in gas trade and politics.

Simultaneously, we will proceed with the assessment of relevant risks and opportunities for the global use of unconventional gas, which could help to understand the complexity of the whole issue.

2. Geology

Unconventional natural gas by definition is understood as a hydrocarbon resource found in low to ultra-low permeability sediments that can be produced neither at economic flow rates nor in economic volumes unless the well is stimulated by hydraulic fracture treatment or accessed by horizontal wellbore, multilateral wellbores or some other technique, which is used to unleash locked natural gas out of the reservoir (Boyer et al., 2011; Holditch – Madani, 2010). There is no difference in chemical composition between conventional and unconventional natural gas (Gény, 2010), the "unconventionality" lies in the process the gas is extracted out of the ground. To produce these resources at commercial rates, the wells must be stimulated by hydraulic fracturing, which is used after the well is reached through a combination of vertical and horizontal drilling. Following Rogner´s definition, we recognize six different types of natural gas, which is reached by these procedures (Rogner, 1997):

- Coal-bed methane (CBM, contained in coal seams);
- Tight gas (gas in low permeable formations);
- Geo pressured gas (gas trapped in deep high-pressured reservoirs);
- Gas hydrates (methane in the form of a crystalline solid that can be found in marine sediments);

- Shale gas (gas trapped within shale formations of sedimentary rocks); and
- Ultra-deep gas (off-shore reservoirs locked in high depths).

To date, most of the attention is put on the development of tight gas, CBM and shale gas, as the other sources are not yet economically or technically available.

Contrary to the conventional natural gas reserves, which are concentrated in several regions such as the Middle East or the Commonwealth of Independent States, where more than 75 % of the known conventional gas is located, unconventional gas in its various forms can be identified all over the world, in the United States, Argentina, Europe, China or Australia. The total reserves of unconventional gas are still not exactly known, because of several reasons. First, there are still enough conventional resources available, which are easier and cheaper to extract, so there has been little incentive for a large scale search for new alternatives and new reserves. Second, there is a big uncertainty about the amount of technically and economically recoverable reserves of unconventional gas, because not enough geological exploration has been done in different parts of the world. Third, the large energy companies, mostly state owned oil and gas giants has shown little or no interest in developing these resources, rather preventing further research due to economic and political reasons. Up to date, there are several estimates of the amount of unconventional gas in the world. The first study about the potential global unconventional reserves of natural gas was made by Rogner, who estimated that there are more than 920 trillion cubic meters (tcm) of unconventional gas in place, which would be double the amount of all conventional sources of natural gas (Rogner, 1997). This assumption is based on the number of total reserves, disregarding the technical and economic aspects of the resource development. The latest estimates come from the International Energy Agency (IEA), which count the remaining technically recoverable resources of unconventional gas. Using the IEA methodology, there are more than 330 tcm of unconventional gas, of which 208 tcm are shale gas reserves, 76 tcm tight gas and 47 tcm CBM (IEA, 2012). These estimates take into account the uncertainties of the statistical reporting by certain countries as well as the difficulties with exact research of unconventional gas in the form ultra-deep gas or gas hydrates.

Despite the inaccurate assumptions about the unconventional reserves of natural gas, one even more important factor to be considered is the geographical distribution of these resources. The largest reserves are supposed to be in China, with estimates of more than 36 tcm of technically recoverable gas from shale and CBM reservoirs, followed by the United States unconventional gas deposits with more than 24 tcm of natural gas, Argentina with almost 22 tcm, Mexico with more than 19 tcm of shale gas reserves, South Africa and Australia with CBM reserves of more than 13 tcm and 11 tcm respectively (EIA, 2011). Russia, as a country with the largest conventional reserves of natural gas, is also supposed to possess large reserves of unconventional gas, mainly in the form of CBM in total volume of more than 84 tcm of gas in place (Lee, 2010). According to Baker Hudges, a technology engineering company in the oil and gas industry, also Saudi Arabia may hold significant reserves of shale gas estimated at 18 tcm, which would make the country the fifth largest reserves holder in the world (Mahdi, 2012).

Following different studies about the potential reserves of unconventional natural gas (Stevens, 2010; Gény, 2010; Medlock, 2011; EIA, 2011; IEA, 2012), several crucial points have to be considered, when thinking about the first dimension – the geology and its transparency. First, there is a huge lack of serious geological research in the world about the real scope of unconventional reserves. This leads to several different estimates about the gas in place and the technically and economically recoverable amount of gas in the world, which discourages decision-makers to put more effort in promoting the development of these resources. Second, there is a frequent confusion in the estimates between the different types of the unconventional resources of gas, which leads to misinterpretation of the statistical data, when assessing the global reserves of unconventional gas. Third, there are huge differences in the estimates of conventional natural gas reserves, which further undermine the relevance of the data about shale gas and other types of unconventional reserves. Fourth, the current energy chessboard with Russia and other energy rich countries as the energy superpowers, generate great political as well as economic pressures on the markets to hinder a fast global development of unconventional oil and gas. Despite these facts, unconventional gas has a huge perspective and it can contribute to a new energy landscape of the world.

3. Economic implications

Economic factors play a crucial role in developing the abundant unconventional resources of natural gas. Parker distinguishes between domestic and external economic effects. In the first case, the economy creates enough domestic supplies, reduces import dependency and creates a more positive balance of payment. It also reduces prices on the market and lowers costs for the industries, thus making them more competitive. The external effects are related to increased global supplies, which are located into new regions, decreasing supply concentration and price volatility on the market (Parker, 2010). Rogner argues that the resource availability is directly connected with fluctuating prices. When the prices are increasing (as seen between 2005 and 2008, when the prices of energy reached record highs), previously uneconomical resources are becoming more profitable, which stimulates the industry to produce more gas, also from other than conventional reservoirs. The vision of higher profits increases investments in research and development of new technologies, which creates more added-value. The more deposits become technically available through improved extraction technologies, the more the production costs are reduced, stimulating even more exploration and production. But after a period of increasing supply, prices tend to decline. Companies have no more incentives to develop new wells and technology development is also abandoned. In the short term, the positive effect is an increase in exploration and productivity. In the long term, falling prices lead to stagnating and even shrinking production base and declining reserves-to-production ratios, which raise future price expectations, and the cycle begins anew (Rogner, 1997).

The development of domestic unconventional resources bears certain economic risks as well. The most evident is the fast depletion of the unconventional wells, which increases and costs related to further geological survey and building more drilling platforms than compared to the conventional wells. According to a report by Stevens, the US experience on the Barnett Shale Play has shown that the wells are depleting by 39 % in the first two years, by 50 % in the first three years and by 95 % in ten years. Thus, shale wells might have a life of 8 to 12 years, compared with conventional gas wells with a lifetime of 30 to 40 years (Stevens, 2010). Another factor is that the fast development of unconventional gas can present a hindrance to the increase of renewable energy in the overall energy mix. It will be very uncertain, whether the decision-makers will support the promotion of another hydrocarbon, or they will risk the skip to a green energy revolution. For some, shale gas is a transition stage, which creates enough space for renewables to settle as the leading form of energy. We have to be careful not to use cheap gas as an excuse for a weak development of clean sources of energy such as solar or wind.

On the other hand, we have been witnesses of multiple positive economic effects of unconventional gas development, mostly in North America. The rising demand for energy in the emerging economies since the beginning of the 21st century transformed the global markets. Due to the record prices for oil and growing concentration of remaining resources, the United States started to search for a cheaper and more available source of energy. Unconventional gas was only one of several options, but thanks to the technological supremacy, a long tradition in the oil and gas industry and a favorable regulation environment, the US companies found a bonanza in the shale gas industry. The high premium for gas induced innovative production techniques such as horizontal drilling and hydraulic fracturing. These technologies enabled economically feasible and large scale extraction. Natural gas production has increased by 28 % since 2005 and in 2011 about a third of domestic production came from shale gas (O´Keefe, 2012). According to a recent study by the IHS, by 2015, the share of US natural gas produced from unconventional sources is expected to increase to 67 % and by 2035 it will be more than 79 % of overall domestic production. This development could induce more than 3.2 trillion USD of new investment and create 1.4 million new job opportunities (Bonakdarpour - Larson, 2012). Despite the oversupply on domestic market, which resulted in low prices at the level of 2 – 2.5 USD/MMBtu (EIA, 2012), which should have discouraged new well discoveries and new extraction, the US is further increasing its production and is now looking to become a net exporter of natural gas to other markets like the EU or Japan, where the market price is much higher. This could lead to lower deficit in balance of payment and strengthen the efforts to energy independence.

4. Environmental implications

Environmental issues are the most challenging when talking about the future prospects of unconventional gas development. The main reason for the increased environmental impact of unconventional gas development is the nature of these resources themselves. They are difficult to extract because they are found in very tight or low permeability formations that prevent their flow to the surface. Therefore, drilling and other production activities can be more invasive and have a larger environmental impact, not just due to the large amount of drilling rigs, which is much higher than compared to conventional drilling, but also due to the usage of fracturing fluids, which contain chemicals such as benzene, toluene, formaldehyde or hydrochloric acid (Rowe – Fortunato, 2010), elements that could cause health problems such as headaches, dizziness, muscle contractions or even cancer. These could easily get into the freshwater aquifers and contaminate water supplies for the whole region. Other problem is related to the extensive use of water during the extraction process. IEA estimates that the total amount of water used in a well, can reach up to 20 000 cubic meters (IEA, 2012). This could present a serious issue for some countries, especially in arid and semi-arid regions such as South Africa, Australia or China.

The production of unconventional gas can also contribute to atmospheric concentration of GHG and affect local air quality. During the production process, methane, a potent greenhouse gas, can flow into the atmosphere through venting and leakages in the wells and contribute to smog formation. From a longer point of view, excessive extraction of unconventional gas can lead to faster increase of global warming, because methane emissions from shale gas are approximately 40 to 60 % higher than from conventional gas. According to a study by Howarth and Santoro, in a 20 years' time horizon, shale gas has a larger GHG footprint than coal, because of methane released during the extraction phase (Howarth – Santoro, 2012). Experts also raise attention about the effect of shale gas development on the renewable energy industry. Since natural gas has been cheaply available, at least in the US, concerns about the future of wind and solar energy have been raised. Many countries will soon develop their own shale gas resources, but none will have a fully functional, unsubsidized renewable energy market (Parker, 2010).

Nevertheless, natural gas has several advantages over other sources of energy. It is currently an abundant and cheap source of energy, cleaner than oil and coal, more safe than nuclear and in contrary to wind or solar, it can produce electricity on a 24/7 basis. Even the IEA argues in its Golden Rules for a Golden Age of Gas report, that most of the negative environmental impacts can be eliminated by applying simple but strict regulations and rules, which will add only a 7 % premium to the overall financial costs of a well development (IEA, 2012). Stricter regulations could also trigger new practices in other industries, thus creating a strong platform for improved waste water management, GHG emissions reduction or land and air pollution disposal.

5. Geopolitical implications

The current energy landscape is based on a simple exchange matrix. The resources are concentrated in several regions like the Middle East or the CIS with Russia and the Caspian states and the demand is concentrated in other regions such as North America, Western Europe or East Asia. Between these two blocks a relatively stable exchange is in place on a day-to-day basis. But the development of unconventional resources can disrupt this reality and create a new energy scenario for the 21st century.

According to the IEA, natural gas can become the world's second most important energy source after oil. The Agency estimates that global demand could rise by over 50 % between 2010 and 2035 and make up 25 % of the world's energy mix, overtaking coal to become the second largest primary energy source in the world (IEA, 2012). Most of this increase in demand will be covered by unconventional gas such as US shale gas or Chinese CBM. Massive development of these resources in the US and China could challenge and even overcome the market power of all traditional conventional gas producers such as Russia, Qatar or Algeria. Therefore, unconventional gas could be a complete game changer with huge geopolitical implications (Birol, 2012). Transforming traditional importers of natural resources such as the United States or China into net exporters can be a mayor trigger of massive change in the international relations. When Russia and Persian Gulf countries lose their market share and a vital source of income, they will have to find another source of economic growth and political power to prevent domestic uprising suppressed only by generous state subsidies and social spending financed by the increased oil and gas revenues. It is possible that they will lose their international influence at the expense of other countries such as Argentina, Brazil, Australia or Poland. This could be a classical zero-sum game with winners and losers on both sides, but it could also be a trigger for increased competition on the global scale and the end of a highly concentrated gas market. This could bring more benefits to all participants, the buyers as well as the sellers. Traditional players will have to change their market behavior, thus making them more market oriented and open to joint foreign investments and political cooperation. Russia, for example, which had to stop the development of the giant Shtokman field, which was initially planned as a source for LNG exports to the United States, is now looking for cooperation with other big consumers such as China or India and is promoting research cooperation with several other countries to gain new technologies for further and more efficient extraction of natural resources. Increased competition and larger supplies would benefit the consumers with lower prices and more stable supplies, thus strengthening their energy security and economic performance.

It is still too early to talk about a global change in the natural gas trade patterns. Unconventional gas has been widely developed only in the US and other regions are only in the phase of exploring their potential. Some countries has already banned the usage of hydraulic fracturing because of environmental concerns and thus slowed the expansion of shale gas and CBM as new global supplies. The ambivalent political impact of unconventional gas is mostly visible in Europe. There are several potential shale gas plays, especially in Poland, Germany, the Baltics or France. But while France has put a moratorium on shale gas development, Poland´s shale plays are being currently developed by local as well as international companies, hopping to become vital supplies for the EU. Also Russia doesn´t want to be left out of the decision-making on its most prospective market. Since Poland had issued permits for shale gas exploration, Russian companies such as Gazprom, bought 25 % of all permits, gaining significant control over these resources (WEC, 2011). This is a clear signal that Russia is willing to tighten control over Europe despite efforts of its member states to develop its own unconventional resources of natural gas.

6. Conclusion

The development of unconventional gas opens a new cycle in the quest for more energy and more resources. There is enough natural gas to satisfy the rising demand for decades or even a century ahead. Many countries around the world could benefit from plentiful domestic resources and lower their import dependency and thus strengthen their own energy security and give a large incentive for economic growth. But it is a matter of choice. Rising environmental concerns about fracking and political tensions could present a significant barrier for the beginning of a new era in global energy. On the other hand, continuing to rely on hydrocarbon resources will undermine the efforts to develop a green and renewable energy system, which is necessary to tackle climate change and rising GHG emissions. But in the turn of the current development, unconventional gas presents the best alternative for clean, cheap, secure and stable supplies of energy. Investing in new technologies, improving environmental regulations and supporting a global initiative of competitive energy markets could lead to a new "golden age".

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